RUNNING HEAD: Short-term memory for expectancy-incongruent information

The effect of incongruency and cognitive load on short-term
verbatim and gist memory in the Conjoint Recognition paradigm

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ABSTRACT

The present research investigated effects of schema incongruency and cognitive load at encoding on short-term memory. Memory for items that are incongruent with an active schema is sometimes found to be more accurate than memory for schema-congruent items. A recent model predicts that this effect is especially pronounced under cognitive load. Two studies manipulated cognitive load and schema incongruency of study items. Verbatim and gist memory for the items was assessed. According to the attention-elaboration (AE) framework, an incongruency advantage is predicted for verbatim and gist memory that is expected to decrease under cognitive load. According to the Encoding Flexibility model (EFM), as cognitive load increases, verbatim memory should favor incongruent over congruent items and gist memory should be superior for congruent items. Based upon a multinomial model that dissociates verbatim and gist memory, the results provide direct evidence for a verbatim and a gist memory advantage for expectancy-incongruent information, confirming AE predictions. Consistent with the EFM, the verbatim incongruency advantage was increased under moderate (but not strong) cognitive load. An integrative framework is proposed to account for the results.

(180 Words)

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INTRODUCTION

In a seminal article, Hastie and Kumar (1979) presented information congruent or incongruent with a hypothetical target person's traits. Participants were able to recall a larger proportion of incongruent items than congruent items. This incongruency advantage has since then been established in a large number of studies, and it was found to occur both in recognition and in recall tests (for reviews see Rojahn & Pettigrew, 1992; Stangor & McMillan, 1992).

The incongruency advantage has posed problems for schema theories of memory, and some have been modified to accommodate this effect (see Graesser & Nakamura, 1982, for a review). For example, the schema-copy-plus-tag hypothesis (SCTH) assumes that upon encountering an event, an available schema for that event is copied from semantic to episodic memory, and additional tags are added where the event diverges from the schema. The SCTH can explain a recognition memory advantage for incongruent information by assuming that tagged information is more likely to be found in a later memory search than non-tagged information.

Results showing a prominent role of attention and elaboration have subsequently challenged even the more flexible schema-based accounts such as the SCTH. Erdfelder and Bredenkamp (1998) reported a decreased incongruency effect when increased attention, induced by an unusual form of presentation, led to an elaborated encoding of items. This finding is incompatible with the SCTH that cannot accommodate effects of attention on recognition memory for schema-relevant information. In their discussion of the accounts for the incongruency advantage in recognition memory, Erdfelder and Bredenkamp conclude that an attention-elaboration (AE) framework fares best in accounting for the effects. The AE account assumes that expectancy-incongruent information receives more attention than expectancy-congruent

information and is subsequently encoded more elaborately, resulting in a memory advantage for that type of information. In this account, an item's incongruency with a schema or script is one of many possible factors that cause it to receive more attention than other items. To the degree that an item is attended to, it is elaborated with the aim to extract its conceptual meaning. This framework is very similar to Schmidt's (1991) incongruity hypothesis. In his integrative review of effects of distinctiveness on memory, Schmidt proposes that, as an initial response to an item's incongruity with active conceptual frameworks, "an attentional response is evoked in inverse proportion to the degree of overlap between the stimulus and the active information" (p. 537), and, subsequent to this initial attentional response, "controlled processes are carried out, including elaboration, relational processing, and rehearsal" (p. 537). These controlled processes can then lead to enhanced memory performance for unexpected information.

However, both expected and unexpected information are valuable, and a human observer appears to favor both types of information, as Johnston and Hawley (1994) have pointed out. In their Mismatch Theory, they postulate a conceptually driven mechanism that suppresses data-driven processing of expectancy-congruent information and enhances data-driven processing of expectancy-incongruent information. As a consequence, expected information is easily perceived because it matches the observer's expectation; it is also largely perceived as matching the expectation because it does not receive much data-driven processing. On the other hand, unexpected information cannot be understood on the basis of pre-existing, knowledge-based expectations and is thus closely examined by data-driven processes. Analogously, it has been suggested in research on the incongruency advantage that the effect of increased attention for incongruent information could be restricted to the processing of the verbatim or surface level while reading a text or following a discourse, whereas congruent information might be favored at

the level of information integration into a situational model (Erdfelder & Bredenkamp, 1998; see also Kintsch, 1988).

The present research uses multinomial models as a measurement tool that allows disentangling memory for an item's surface from memory for an item's meaning. Specifically, the Conjoint Recognition framework (CR; Brainerd, Stein, & Reyna, 1998; Brainerd, Reyna, & Mojardin, 1999) is used. First, we will establish an incongruency effect within the CR framework. The predictions derived from three competing models – the AE framework, the Encoding Flexibility model (EFM; Sherman, Lee, Bessenoff, & Frost, 1998; Sherman, Conrey, & Groom, 2004), and an integrative model combining both accounts – are then compared with regard to their predictions for the effect of cognitive load on the incongruency advantage in memory.

The Encoding Flexibility Model

Similar to the AE framework, the EFM also focuses on the effects of differential attention on the encoding of surface or perceptual detail. Based on Mismatch Theory, it postulates that expectancy-incongruent information is especially informative, and thus any adaptive cognitive system would need to ensure that this information is encoded and not lost. However, expectancy-incongruent information is assumed to be more difficult to understand than expectancy-congruent information, and thus, it needs to be processed in more perceptual detail than expectancy-congruent information, so that the perceiver can later extract its meaning. This detailed perceptual processing of incongruent information requires cognitive resources that can be taken away from the processing of expectancy-congruent information, because congruent information is easily understood conceptually and needs not be encoded in perceptual detail.

The EFM thus also predicts an attentional asymmetry between expectancy-congruent and expectancy-incongruent information. Contrary to the AE account, however, it postulates that this asymmetry is the result of a mechanism of attention-allocation that is triggered by cognitive load. This yields counterintuitive predictions: When full processing resources are available, the EFM predicts that both congruent and incongruent information are processed in equal detail. In a situation of limited or divided cognitive resources, the EFM predicts that expectancy-congruent information is easily understood conceptually by way of a process that requires few resources, and that the remaining attentional resources are then reallocated towards processing perceptual detail of expectancy-incongruent information, thus resulting in an incongruency advantage in recognition memory. According to the EFM, because in any given situation a human cognitive system will typically have to divide attention between multiple tasks or processing goals, the postulated attention-reallocation mechanism ensures that a maximum of information is extracted from the situation, and that the potentially crucial incongruent information is not lost but encoded perceptually to later extract its meaning.

Sherman et al. (1998) present a series of studies in support of the EFM. When participants were asked to retain an 8-digit number during an impression formation task, they showed better recall and recognition memory for incongruent behaviors, spent more time reading incongruent behaviors, and were faster in identifying peripheral words from sentences that describe incongruent as compared to congruent behaviors. In another study, participants reacted faster to a dot probe when it replaced the sentence describing the incongruent compared to the congruent behavior of a pair presented together on a single screen (Sherman et al., 2004).

These findings are incompatible with the AE framework's prediction that the incongruency advantage *decreases* under cognitive load: The AE postulates that, because the

incongruency advantage depends on attention and cognitive elaboration of incongruent information, it should decrease with the amount of available cognitive (attentional and elaborational) resources. Thus, the available evidence (Erdfelder & Bredenkamp, 1998; Sherman et al., 1998, 2004) appears to be contradictory. The present research aims at contributing evidence towards solving this apparent contradiction.

A modified EFM and an integrative view

Our own evidence suggests that the EFM account might be limited in scope. In previous studies, using various materials and expectancies, we failed to obtain evidence for the Congruency by Load interaction predicted by the EFM (Stahl, 2004, 2006). For example, in one set of studies, occupations were either congruent or incongruent to a gender schema that was activated by the gender-typicality of a first name (see also Macrae, Schloerscheidt, Bodenhausen, & Milne, 2002)¹. In another series, actions or events were either congruent or incongruent with situational expectations derived from action scripts that were activated by the story context (see also Erdfelder & Bredenkamp, 1998). Because both series failed to obtain the predicted interaction, we believe it unlikely that its absence was due to the specific material or type of expectancy. The failure to obtain the predicted interaction might, however, be due to the specific manipulation of cognitive load. In our studies, participants were required to constantly generate random numbers at a rate of one digit every two seconds, a task that can be considered to impose a relatively strong cognitive load (Baddeley, 1996, 1998; Macrae, Bodenhausen, Schloerscheidt, & Milne, 1999). This is especially true in comparison to the relatively moderate digit memory load manipulation used by Sherman and colleagues (Sherman et al., 1998, 2004) that required participants to retain a set of eight digits in memory during the presentation phase. Thus, both manipulations differ with regard to the quantity of cognitive load they impose.

We believe that the different amount or quantity of cognitive load could have caused the results to diverge. The postulated attention-reallocation mechanism might require a minimum of available cognitive resources in order to operate, such that in a cognitive system with limited capacity, it might be successfully triggered and executed only under moderate levels of cognitive load, but might not be effective under conditions of highly disruptive cognitive load. We therefore propose a plausible and straightforward modification of the EFM, namely that the attention-reallocation posited by the EFM is effective only with low or medium levels of cognitive load, but fails to affect encoding when the overall cognitive load exceeds an upper threshold.

The modified EFM thus predicts an inverted-U relation between cognitive load and the perceptual encoding advantage for incongruent items. With increasing cognitive load, a perceptual encoding advantage for incongruent items would first increase until it reaches a maximum at moderate levels of cognitive load; a further increase in cognitive load would cause this perceptual encoding advantage to decrease until it is finally eliminated under highly disruptive loads. Assuming that random-generation as a secondary task exceeds this upper threshold but the digit-load task does not, the modified EFM account is compatible both with the findings obtained by Sherman and colleagues as well as with our own findings.

An integrative model can be formed by combining the modified EFM with the AE account. The EFM predicts interactive effects of congruency and cognitive load on perceptual memory, but it does not address absolute levels of perceptual and conceptual memory. According to AE framework (Erdfelder & Bredenkamp, 1998; Schmidt, 1991), incongruent information is encoded more thoroughly and recognized better than congruent information because it receives a larger share of available attentional resources at encoding. As a

consequence of this attentional advantage, incongruent information is subsequently encoded more elaborately whenever the availability of cognitive resources allows for it. In effect, it is ensured that the meaning of expectancy-incongruent information is not lost. The EFM thus shares a central feature with the attention-elaboration framework. The AE framework predicts an incongruency advantage in perceptual and in conceptual memory. This incongruency advantage depends on elaborative encoding and should thus naturally decrease with the opportunity to elaborate, that is, decrease with the amount of cognitive resources available. An increase in the perceptual incongruency advantage under moderate levels of cognitive load (e.g., Sherman et al., 2004) is not predicted by the AE framework. It is, however, also not incompatible with it, as the framework does not make specific predictions about the kind of information that is attended to under different conditions of cognitive load.

As a third model to be tested, we suggest an integrative combination of both the AE and EFM that (1) shares the AE framework's account of the effects of attention allocation and subsequent elaboration on encoding and memory in general, and that (2) additionally incorporates an attention-reallocation mechanism as postulated by a modified EFM that accounts for the shift in attention allocation toward expectancy-incongruent information under moderate levels of cognitive load. To compare these three accounts, two studies were conducted within the CR paradigm.

The Conjoint Recognition Paradigm

The Conjoint Recognition (CR) paradigm and multinomial model (Brainerd, Stein, & Reyna, 1998; Brainerd, Reyna, & Mojardin, 1999) have been proposed as a means to separate contributions of memory for an item's surface – verbatim memory – from memory for an item's meaning – gist memory – to recognition performance. By providing methodological tools to

separate verbatim and gist memory, the CR paradigm allows for a more refined assessment of differential encoding of expectancy-congruent and -incongruent information.

Note that the attentional asymmetry proposed by the EFM is based on a perceptual versus conceptual distinction, whereas the CR framework is based on a verbatim versus gist distinction. Although not identical, the two distinctions are highly similar. Furthermore, research on the EFM has operationalized the perceptual-conceptual dimension basically in terms of verbatim versus gist information: Studies of the EFM used sentences as stimuli, presented in written form, and perceptual memory was assessed as memory for the exact wording of a stimulus; other perceptual detail was not helpful for performance in the memory test (nor for extracting the item's conceptual meaning later on). Therefore, perceptual memory as assessed in work on the EFM means memory for the wording of a sentence, and this is precisely what is assessed by verbatim memory in the CR paradigm. Conceptual memory was operationalized as memory for the abstract meaning of the action described by a sentence (e.g., a trait summarizing the described behavior). Similarly, in the CR paradigm, gist memory assesses the retention of the action itself, regardless of the exact words that were used to describe it. For these reasons, it is possible to use the CR paradigm's verbatim memory measure to assess memory for the perceptual surface of verbal stimuli, and to use the CR paradigm's gist memory measure to assess memory for the conceptual meaning of stimuli. A caveat is however that conclusions drawn with regard to EFM in this chapter are conditional on the assumption that it also applies to the verbatim – gist distinction. Future work, assessing memory for non-linguistic perceptual detail such as is relevant for behavior observed in the real world – for example, using complex scenes as stimuli – may determine whether verbatim memory and memory for non-linguistic perceptual detail function differently given different amounts of cognitive load and expectancies.

The CR paradigm is based on Fuzzy Trace theory's (e.g., Brainerd & Reyna, 2002) notion that, at encoding, a verbatim and a gist trace is created for each item. In a recognition memory test, given an old item as probe, Fuzzy Trace theory thus postulates three possible mnemonic states: (1) The verbatim trace of an item (e.g., the exact spelling of a word or wording of a sentence) can be accessed. The item can then correctly be classified as old, regardless of memory for the item's gist. (2) The gist trace of an item (e.g., its conceptual meaning) can be accessed, but not its verbatim trace. FTT postulates that this is also sufficient for judging an item old. (3) Neither verbatim nor gist trace can be accessed; in this case, responses reflect guessing processes that are subject to expectancy-based biases.

Verbatim and gist memory processes are disentangled within the CR framework on the basis of the following procedure: In a CR memory test, participants are presented with three types of probes, (1) *target probes* that are perceptually and conceptually identical to the target, (2) *related probes* that are conceptually identical to the target (i.e., share the same gist trace), but differ in perceptual or surface detail (i.e., their verbatim trace), and (3) *unrelated probes* that share neither conceptual nor perceptual information with the target item. Participants are asked to discriminate between targets, related probes, and unrelated probes. By introducing different memory test instructions, the CR paradigm realizes two different conditions in a between-participants design. Under the *T* (target) condition, participants are instructed to accept only target probes and to reject both related probes and unrelated probes. Under the *R* (related) condition, participants are instructed to accept only related probes and to reject both targets and unrelated probes. To the extent that participants have encoded the perceptual or verbatim detail of a target, they can discriminate that target from a related probe (that shares the same gist but differs with regard to verbatim information). To discriminate between a target and an unrelated

probe, participants can employ both conceptual (i.e., gist) or perceptual (i.e., verbatim) information about the target. Gist information can be used to discriminate between related and unrelated probes.

Multinomial processing tree models are useful tools in disentangling cognitive processes (Riefer & Batchelder, 1988) that have been used very successfully in cognitive and social psychology (see Batchelder & Riefer, 1999; Erdfelder, in press; and Stahl, 2006, for reviews). The multinomial processing tree model of the CR paradigm (Brainerd et al., 1998, 1999) builds upon the CR procedure to provide a framework for the separate measurement of the contribution of verbatim and gist traces, as well as of guessing tendencies.

Figure 1

Figure 1 shows a tree diagram of the model. The upper tree diagram represents the processes triggered by a target probe at test. In case its verbatim trace can be retrieved (with probability V ; see topmost branch), the item is correctly accepted as a target under the T condition (as indicated by the first column on the right) and correctly rejected under the R condition (as indicated by the second column). In case the verbatim trace cannot be accessed (with probability $1 - V$), but the gist trace is accessible (with probability G ; second branch), it is also accepted as a target under the T as well as the R conditions. If, with probability $(1 - V)(1 - G)$, neither the verbatim nor the gist traces can be accessed, participants are left to guess whether the item had been presented before (with probability B ; third branch) or not (with probability $1 - B$; fourth branch). The model thus postulates that a response in the CR memory test is a combined result of the operation of three basic processes: accessing the verbatim trace (V), accessing the gist trace (G), and guessing (B).

Different parameters V' and G' are estimated for memory processes involved in recognition memory for related probes because they assess different aspects of memory than the parameters V and G . Consider the middle diagram in Figure 1 that represents a related probe being presented at test. Because target items are expected to be better retrieval cues for their own memory representations than related probes, the probability V' for successfully accessing the target's verbatim trace, given the related probe as retrieval cue, is expected to be smaller than that for accessing the target's verbatim trace given the target itself as a cue, $V' < V$. If successfully retrieved, the target's verbatim representation can be compared to that of the probe; if it does not match the probe, it is rejected under the T condition (and accepted under the R condition; topmost branch of the middle tree diagram). In earlier applications of the CR paradigm, the corresponding parameter estimates have tended to be relatively small (Brainerd et

al., 1998, 1999), and, given the comparatively high cognitive demands resulting from the dual-task procedure that we implemented in the present experiments, we expect even lower estimates. If the target's verbatim trace is not retrieved (with probability $1 - V'$), but its gist trace can be accessed (with probability G'), the item will be accepted (second branch); if neither memory trace can be retrieved, participants respond by guessing (accepting the probe with probability B and rejecting it with probability $1 - B$; third and fourth branch). For unrelated foils, a response is determined by guessing processes (bottom diagram).

Participants tend to show better memory performance under the T condition than under the R condition because it is easier to judge items that were presented earlier than items that merely resemble such earlier-presented items. Consequently, participants might show different response tendencies in the T and R conditions. Reflecting this, the model allows response bias parameters to differ between the T and R conditions. The multinomial processing tree model of the CR paradigm (the CR model) has six parameters – two represent the probability of accessing the verbatim trace (V and V'), two that represent the probability of accessing the gist trace (G and G'), and two that represent guessing tendency under the T and R conditions (B_T and B_R).

Given six empirical probabilities that are free to vary (*accept* responses to targets, related probes, and unrelated probes under the T and the R conditions), the CR model is saturated, meaning that it does not allow for a test of model fit because it has as many parameters as independent data points. However, it is desirable to test whether the model can explain the data before interpreting parameter values and drawing substantive conclusions from the results. In order to allow for a goodness-of-fit test, we simplified the model by restricting the V' parameters to zero. As discussed above, we expected the V' estimates to be negligible, if at all greater than zero. This restriction yields additional degrees of freedom that allow for a goodness-of-fit test.

The goodness-of-fit test assesses whether the model, including the auxiliary assumption of no substantial contribution of the V' parameter, can account for the data. Given model fit, this auxiliary assumption is corroborated, and estimates of the verbatim and gist parameters obtained under the different conditions can then be compared to test our hypotheses.

We conducted two experiments within the CR framework that include conditions of low, moderate, and high levels of cognitive load. Experiment 1 compared an 8-digit memory load condition and a random-generation load condition to a control condition with no secondary task. In order to demonstrate that the effects obtained in Experiment 1 do not depend on the different qualities of cognitive load imposed by these different load conditions, Experiment 2 used a single secondary task to implement both medium and high levels of cognitive load.

The following predictions can be derived for the parameters of the CR model. First, the AE framework assumes that the availability of cognitive resources governs the amount of perceptual detail that can be encoded in the elaboration phase, and thereby, the magnitude of the verbatim memory advantage for incongruent information. Therefore, limiting the available cognitive resources by way of introducing a secondary task would lead to a monotonical decrease of the incongruency advantage in verbatim memory with increasing cognitive load (i.e., across the low, medium, and high-load conditions).

Second, the attentional reallocation mechanism postulated by EFM predicts that, under cognitive load, attention is actively shifted toward encoding perceptual detail of expectancy-incongruent information. It follows that an incongruency advantage in verbatim memory is expected under the medium and high-load conditions but not, or to a lesser extent, in the low-load condition.

Finally, the integrative framework presented here predicts an inverted-U function for the verbatim incongruency advantage: Under low load, sufficient resources are available, and detail of both congruent and incongruent information is therefore encoded. Under medium levels of load, resources are limited, and attention is directed toward encoding expectancy-incongruent information in greater detail, causing a verbatim incongruency advantage. Under high levels of load, a selective allocation of attention can no longer be maintained because sufficient cognitive resources are not available, and the verbatim incongruency advantage is expected to disappear.

Again, we are careful to note that, despite their considerable overlap, the perceptual-conceptual and the verbatim – gist distinctions are two theoretically separate dimensions and cannot be considered identical. For example, in the present paradigm, memory performance measured by the verbatim parameters may not be purely perceptual, and performance assessed by the gist parameters may not be purely conceptual. However, it has been shown that the CR paradigm can be used as a measurement tool to disentangle memory for the surface of verbal stimuli from memory for their meaning (e.g., Brainerd et al., 1999), and as already pointed out above, research on the EFM has operationalized perceptual and conceptual memory in a practically identical manner. Perceptual memory was said to be present when the processing of a word which was peripheral to the meaning of a sentence describing the behavior of a person was facilitated in a word-identification task. This parallels the present approach, where perceptual encoding was said to be present to the extent that a target sentence could be discriminated from related foils that differed in some peripheral detail of its wording (i.e., with regard to verbatim information). Conceptual memory was said to be present when a trait that summarizes the behavior described in a sentence was facilitated in a word-identification task; this parallels the

present operationalization where two sentences that describe the same behavior using different words are considered conceptually equivalent (i.e., with regard to gist information).

To conclude, in the present work, the CR model is used as a measurement tool to disentangle these memory processes. As is the case with such models, the theoretical interpretation of the parameters depends on the empirical paradigm they are applied to (Brainerd et al., 1998; Brown & Gorfain, 2004). As outlined above (and illustrated in more detail below), the CR model's verbatim and gist parameters as used in the present work can be interpreted as measures of memory for the perceptual surface of sentence stimuli and their conceptual meaning, respectively.

Experiment 1

We first aimed at replicating the increased perceptual incongruency advantage that Sherman et al. (1998, 2004) found using the digit-load task. In the same experiment, we sought to replicate our own findings that no such increase was evident under the more demanding random-generation secondary task.

In previous work, the AE framework was tested using expectancies based on action scripts (e.g., Bower, Black, & Turner, 1979), whereas the EFM was tested in the context of expectancies based on social stereotypes. A secondary goal of the present work was to examine whether the EFM can be supported beyond the domain of social stereotypes, and for this reason, congruency and incongruency were defined with respect to action scripts (i.e., actions typically occurring during a visit to a restaurant) in this chapter.

In an impression-formation task, participants were presented with expectancy-congruent (e.g., *they study the menu*) and expectancy-incongruent events (e.g., *she finds a hair in her soup*) that were integrated with the filler items to form sentences describing the action-script situations.

At test, participants were presented with target probes (i.e., sentences from the impression-formation phase), related probes (i.e., sentences describing events presented in the impression-formation phase, but with slightly different wording; e.g., *she discovers a hair in her soup*), and unrelated probes (i.e., sentences describing events that could occur in the scripted situation but that were not presented in the impression-formation phase). Note that *unrelated* probes were thus defined by their lack of relatedness to the meaning of the specific target actions; unrelated probes were, however, related to the action script as a whole (i.e., because they represented actions congruent and incongruent with the scripts).

As a consequence, in the present application of the CR model, its parameters can be interpreted as follows. First, the verbatim memory parameters measure the extent to which participants can discriminate between targets and related probes, that is, the extent to which they have encoded the exact wording of the sentence, allowing them to discriminate between the original and a slightly rephrased version of a sentence describing the same action or event. Verbatim memory, that is, encoding of the exact wording of an item, is expected to be stronger for incongruent items as discussed above.

Second, the gist memory parameters measure the extent to which participants have encoded the meaning of an action or event, which would allow them to accept targets and related probes but reject unrelated probes. Thus, gist memory parameters must be interpreted as measures of memory for the meaning of specific actions, instead of memory for the meaning of the action script schema. Given that the meaning of script-incongruent actions or events might be more distinctive, an incongruity advantage may well obtain for gist parameters as well.

Finally, guessing parameters assess participants' tendency to accept distracters as old that are unrelated to sentences presented in the impression-formation phase. Because those distracters

are, however, related to the action script, guessing parameters are expected to differ between congruent and incongruent items, reflecting expectancy-based guessing strategies (e.g., Stangor & MacMillan, 1992)

Method

Participants. Ninety students from the Universities of Bonn and Freiburg participated for a monetary compensation of 6 Euro. Data from one participant was excluded from analysis because of repeated failure to understand the memory test instructions. Of the remaining 89 participants, 55 were male and 34 were female; age varied between 18 and 39 ($M = 24$).

Materials. Five of the nine action-script situations used by Erdfelder and Bredenkamp (1998; e.g., visiting a restaurant) were randomly selected for each participant anew. For each script, four highly typical (i.e., script-congruent) and four atypical (i.e., script-incongruent) actions were available. Of these, two congruent and two incongruent items were randomly selected for each participant anew to be included in the story. In sum, ten congruent and ten incongruent critical items were presented. Additional script-relevant items of medium typicality were randomly selected as fillers. The selected expectancy-congruent (e.g., *they study the menu*) and expectancy-incongruent items (e.g., *she finds a hair in her soup*) were integrated with the filler items to form sentences describing the action-script situations. Filler sentences that connected the scripted situations completed the story. Of the presented congruent and incongruent actions, one for each script was presented during the memory test as a target probe (i.e., using the same words as during presentation), and the other was presented as a related probe (i.e., with different wording, e.g., *she discovers a hair in her soup*). The two congruent and incongruent actions from each scripted situation that were not presented in the story were used as unrelated probes during the memory test. Unrelated probes were not related to the meaning of the

specific target actions; however, they were related to the action script as a whole (i.e., because they represented actions congruent and incongruent with the scripts). In sum, a total of 40 probes (10 target probes, 10 related probes, and 20 unrelated probes) were presented in the memory test.

Design. A 3 (Cognitive load: no-load, digit-load, random-generation) x 2 (Instruction: T vs. R) x 2 (Congruency: congruent vs. incongruent) x 3 (Probe type: target, related, unrelated) design with repeated measures on the last two factors was realized.

Procedure. The experiment was conducted in individual computerized sessions. Participants were informed that they would participate in a study on person perception in which they would be reading stories about two individuals and were to form an accurate impression of each person, as afterwards they would be asked to answer a number of questions about each individual. They were also instructed that the study investigated information processing under distraction, and that during the course of the experiment they would be required to engage in a secondary task that was to be practiced next. To keep conditions as similar as possible, all participants practiced the random-generation task (Baddeley, 1998) that requires continuous generation and pronunciation of randomly selected digits between 1 and 9 at a rate of one digit every two seconds. Participants in the random-generation group did actually perform this task during the presentation of the action script story. The generated numbers were recorded on tape. Participants in the digit-load group were instead presented with a random eight-digit number in which every digit appeared only once, and they were given 30 seconds to memorize the number. They were instructed to keep the number in memory until asked to reproduce it. Participants in the no-load group did not perform any secondary task.

Following the secondary-task instructions, participants were presented with the action script story. Participants were told that they would be reading a story about a day in the life of

Peter W., a student, and were instructed to imagine what kind of person Peter was. The sentences comprising the story were presented sequentially. Each sentence remained on screen for 8 s and was replaced by the next sentence after an inter-stimulus-interval of 100 ms. In the digit-load condition, participants were instructed to retain the number in memory during presentation of sentences. In the random-generation condition, participants were instructed to generate random numbers at a rate of four digits per sentence.

After the last sentence had appeared, participants in the digit-load group were instructed to enter the retained number on the keyboard. All participants then engaged in two filler tasks: First, they read a comic strip story about a second person for a duration of 15 minutes. In the second task, they assigned each of a list of 50 adjectives to either Peter W. or the person from the comic strip, depending on whom they considered the adjective described better. The filler phase lasted approximately 20 minutes.

Upon completion of the filler tasks, an unexpected memory test for the items from the Peter W. story followed. Participants under the T instruction condition were asked to indicate whether a memory probe was *identical* to an item presented in the story (i.e., described with exactly the same words) or not. Participants under the R condition were asked to indicate whether a memory probe described an action or event that was included in the story but with *different* words from those used in the story. The instructions were clarified with a number of examples, and participants' correct understanding of the instructions was tested before they could proceed to the memory test. In case of failure on that test, instructions and examples were repeated until the test was passed. Participants were presented sequentially with the 40 probe items and indicated their response by pressing one of two keys on a standard computer keyboard.

Finally, participants answered a number of demographic questions, received feedback on their memory performance, and were debriefed, thanked, and dismissed.

Results

We first report the goodness-of-fit test, followed by analyses of the verbatim, gist, and bias parameter estimates. In analyzing gist memory estimates, we tested first whether we could simplify the model by restricting gist parameters to be equal across type of memory probe (i.e., restricting $G = G'$).

A sensitivity power analysis (Erdfelder, Faul, & Buchner, 1996) revealed that, with $N = 3560$, $df = 6$, and $\alpha = .05$, and a power of $1 - \beta = .99$, the goodness-of-fit test was capable of detecting very small deviations from the model ($w = .09$; see Cohen, 1988, chap. 7). The model fitted the data, $G^2(6) = 10.17$, $p = .12$, establishing that no such deviations were evident. Table 1 presents the resulting parameter estimates.

Verbatim memory. An incongruency advantage in verbatim memory was observed, $\Delta G^2(3) = 9.72$, $p < .05$. Separate tests revealed that this was significant only under the digit-load condition, $\Delta G^2(1) = 7.98$, $p < .05$, but neither under the no-load nor the random-generation conditions, both $\Delta G^2(1) < 1$, *ns*, supporting the predicted inverted-U shape for the verbatim incongruency advantage. An overall effect of cognitive load on verbatim memory was observed, $\Delta G^2(4) = 15.27$, $p < .05$. This effect was observed for incongruent items, $\Delta G^2(2) = 11.16$, $p < .05$, but not for congruent items, $\Delta G^2(2) = 3.73$, *ns*. Separate tests revealed a significant difference between the digit-load and the random-generation conditions, $\Delta G^2(1) = 10.93$, $p < .05$; neither the difference between the no-load and digit-load conditions nor between the no-load and random-generation conditions were significant, $\Delta G^2(1) = 1.43$ and 3.67 , both *ns*. In sum,

cognitive load did not simply reduce overall levels of verbatim memory, but interacted with congruency to produce the inverted-U pattern predicted by the modified EFM.

Gist memory. Gist memory was not affected by the type of test probe, $\Delta G^2(6) = 6.95$, *ns*. For the sake of simplicity, we collapsed across this factor after initial analyses revealed that this restriction did not affect the pattern of results. An incongruency advantage in gist memory was found, $\Delta G^2(3) = 23.49$, $p < .05$. This effect was evident under the no-load and the random-generation conditions, $\Delta G^2(1) = 15.20$ and $\Delta G^2(1) = 6.88$, both $p < .05$, but was not significant under the digit-load condition, $\Delta G^2(1) = 1.40$, *ns*. Cognitive load only weakly affected gist memory: The main effect of cognitive load on gist memory fell short of statistical significance, $\Delta G^2(4) = 8.49$, $p = .06$. Post-hoc tests revealed that cognitive load affected gist memory for incongruent items, $\Delta G^2(2) = 7.22$, $p < .05$: A reduction in Gist memory between the no-load and the digit-load conditions was evident, $\Delta G^2(1) = 6.04$, $p < .05$; no further reduction was obtained under the random-generation condition, $\Delta G^2(1) < 1$, *ns*. Cognitive load did not affect gist memory for congruent items, $\Delta G^2(2) = 1.71$, *ns*.

Guessing. Instruction affected guessing, $\Delta G^2(6) = 14.66$, $p < .05$. Separate tests revealed that no effects of instruction were observed on guessing for congruent items, $\Delta G^2(3) < 1$, *ns*. However, such an effect was found for incongruent items, $\Delta G^2(3) = 13.46$, $p < .05$: Participants were more willing to accept an unrecognized incongruent item as old under the R condition. Guessing was biased towards congruent items, $\Delta G^2(6) = 346.29$, both under the T and the R conditions, $\Delta G^2(3) = 226.29$, and $\Delta G^2(3) = 135.49$, respectively, all $ps < .05$. Cognitive load affected guessing, $\Delta G^2(8) = 37.92$, $p < .05$; this effect was restricted to congruent items, $\Delta G^2(4) = 30.45$, $p < .05$, and was not observed for incongruent items, $\Delta G^2(4) = 7.08$, *ns*. For congruent items, more conservative guessing was observed under the digit-load condition compared to the

no-load condition, $\Delta G^2(2) = 13.74$, as well as compared to the random-generation condition, $\Delta G^2(2) = 28.66$, $p < .05$; no difference was observed between the no-load and random-generation conditions, $\Delta G^2(2) = 2.72$, *ns*.

Discussion

The pattern predicted by the modified EFM was observed in the parameter estimates of verbatim memory. Whereas verbatim memory for incongruent items increased when a moderate load was induced, it decreased again under a more disruptive cognitive load. Simultaneously, verbatim memory for congruent items was not significantly affected by cognitive load but tended to decrease monotonically. This pattern supports the assumption of a reallocation of attentional resources towards perceptually encoding incongruent items under moderate cognitive load: More attention was paid to incongruent information than to congruent information, especially under moderate load. As predicted, however, the attention-reallocation mechanism failed to be effective under highly disruptive cognitive load: The random-generation secondary task significantly reduced verbatim memory for incongruent items and eliminated the perceptual incongruency advantage.

Consistent with the AE framework, an incongruency advantage was also obtained in gist memory, consistent with Erdfelder and Bredenkamp's (1998) results. This advantage was not present, however, under the digit-load condition, apparently because cognitive load caused a reduction of gist memory for incongruent items in that condition. This pattern is compatible with the interpretation that cognitive resources were drawn from the processing of the meaning of incongruent information and transferred to the processing of its surface form, as predicted by the EFM.

Guessing tendency was strongly affected by expectancies: When uncertain about a probe's status, congruent probes were much more likely to be accepted than incongruent probes. As Stangor and MacMillan (1992) have shown, an expectancy-based guessing bias is the single most pervasive phenomenon in the literature on memory for congruent and incongruent information.

The finding of greater memory for the gist of schema-incongruent information appears to be at odds with findings from the person-memory literature, specifically with the finding that recall (but not recognition sensitivity) increasingly favors congruent information under conditions of cognitive load, and the finding of increased use of stereotypes in judgment tasks under conditions of cognitive load. These effects are sometimes taken to reflect schematic or gist memory but are also discussed as reflecting schema-based reconstructive retrieval processes or biases. For example, it is likely that abstract schematic information is used in recall tests as background knowledge for reconstructive processes in the manner of a generate-recognize strategy (see Bellezza, 2003, for an evaluation), and in recall and recognition tests as a basis for guessing processes (e.g., Stangor & MacMillan, 1992). At first sight, a gist advantage for incongruent information might appear incompatible with the prevalent finding of strong use of schema knowledge in recall and judgment. However, a closer look will reveal that there is in fact no discrepancy. In the present research, gist memory is defined as memory for the specific action described by a sentence in the story, as opposed to memory for the relevant schema itself (i.e., the action script). Gist as defined in the current paradigm thus does not correspond with the level of abstraction of the schema but inhabits a lower level of abstraction. Gist memory in the current paradigm is in a sense orthogonal to memory for the schema: It denotes memory for a single specific action, and such an action can be congruent or incongruent with the relevant schema

(e.g., the restaurant script). This means that knowledge of the schema in general (i.e., of actions that typically occur in a restaurant situation) is of no use in deciding whether a *specific* schema-congruent action that is presented as a probe in the memory test (e.g., *Peter asked for the menu*) has been mentioned in the story or not, regardless of its wording. Thus, whereas we believe it likely that participants had good memory for the more abstract essence of the restaurant situation (i.e., the restaurant script itself), this memory could not affect the less abstract Gist memory as it was defined in the present paradigm. Instead, memory for the schema affected reconstructive processes at a more abstract level, as reflected in congruency effects on the parameters measuring guessing bias.

In sum, we found good support for a reallocation of resources as proposed by the modified EFM. Simultaneously, Experiment 1 also illustrates the limits of the resource reallocation mechanism: When participants were put under a condition of strongly disruptive cognitive load (i.e., they had to perform the random-generation secondary task), the verbatim memory advantage for incongruent information disappears. This effect is in accord with the modified EFM as well as with the AE account.

Experiment 2

As pointed out above, the two secondary tasks used in Experiment 1 differ with regard to the quantity of the cognitive load they induce. According to Baddeley's model of working memory (Baddeley & Hitch, 1974; for a recent review see Baddeley, 2003), they also differ with regard to the quality of cognitive load. The rehearsal of an eight-digit number presumably loads verbal working memory components such as the phonological loop and the associated rehearsal process, whereas the task of generating random sequences of digits presumably additionally recruits the central executive component. Both tasks thus differ in the quality and quantity of the

cognitive resources they recruit. Whereas both types of secondary tasks likely involve some aspect of verbal processing (covert rehearsal in case of the digit-load task; overt generation of random digits and memorizing previously generated digits in case of the random-generation task), random generation has been shown to strongly involve central executive processes (e.g., Baddeley, 1998). It could therefore be argued that the pattern of results obtained in Experiment 1 could be attributed to the qualitative differences between the two secondary tasks. To be able to draw a firm conclusion that quantitative differences are sufficient to obtain the inverted-U pattern of results – that is, that the *amount* of available cognitive resources indeed affects encoding flexibility – we devised a more rigorous test of the modified EFM, using a secondary task that varies cognitive load only along the quantitative dimension.

For this purpose, we used the *random interval repetition* task that has been shown to affect central-executive processes (RIR; Vandierendonck, de Vooght, & van der Gotten, 1998). In this task, participants are required to respond as fast as possible to acoustic signals generated by the computer in random intervals. We manipulated size and variability of the intervals to vary the amount of cognitive resources required to perform this task.

Method

Participants. Ninety University of Freiburg students participated in exchange for a monetary reward of 7 Euros. Data from two participants had to be excluded because of repeated failure to understand the memory test instructions. Of the remaining 88 participants, 57 were male and 31 were female; age varied between 19 and 45 ($M = 23$).

Materials. The same materials as in Experiment 1 were used, with the exception that all of the nine available scripted situations were presented in order to further increase test power. As a result, the story contained 18 script-congruent and 18 script-incongruent critical actions. Of

each of these, one half was presented as target probes, and the other half was presented as related probes on the memory test. The remaining 36 critical actions that were not included in the story were used as unrelated probes. Altogether, 72 probes were presented in the memory test.

Design. A 3 (Cognitive load: none, medium, high) x 2 (Instruction: T vs. R) x 2 (Congruency: congruent vs. incongruent) x 3 (Probe type: target, related, unrelated) design with repeated measures on the last two factors was realized.

Procedure. The procedures were identical to those of Experiment 1, with the exception of the secondary task. Before presentation of the action script story, the RIR task was practiced by all participants. They were instructed to press the space bar as fast as possible after a beep tone was presented. They practiced this task in two blocks of 30 seconds each, with intervals between beeps differing in size and variability between blocks. During presentation of the action script story, participants in the medium-load and the high-load conditions were instructed to press the space bar in reaction to beep tones presented at random intervals. In the medium-load condition, beeps were presented at one of four possible, randomly selected, fixed intervals (1000, 1500, 2000, or 2500 ms). In the high-load condition, intervals were shorter (300, 500, 1100, or 1300ms), and an additional random jitter of up to ± 200 ms was added. The high-load condition thus required roughly twice as many RIR reactions as the medium-load condition. Participants in the no-load condition performed no secondary task.

Results

RIR reaction times were not affected by item congruency, $F(1, 118) < 1$. Due to the increased number of probes presented in the memory test, the goodness-of-fit test was even more sensitive: It was capable of detecting very small deviations from the model ($w = .07$) with a power of $1 - \beta > .99$, $\alpha = .05$, and $N = 6336$. The model again fitted the data, $G^2(6) = 11.82$, $p =$

.07, demonstrating that no such deviations were detected. Parameter estimates are presented in Table 2.

Verbatim memory. We observed an overall incongruency advantage in verbatim memory, $\Delta G^2(3) = 22.90, p < .05$. Separate tests revealed that this effect was significant only under the medium-load condition, $\Delta G^2(2) = 20.09, p < .05$, but neither under the no-load nor the high-load conditions, $\Delta G^2(1) = 1.11$ and 1.71 , both *ns*, again supporting the predicted inverted-U-shape for the verbatim incongruency advantage. A marginally significant effect of cognitive load on verbatim memory was observed, $\Delta G^2(4) = 8.5, p = .07$, that was significant for incongruent items, $\Delta G^2(2) = 6.99, p < .05$, but not for congruent items, $\Delta G^2(2) = 1.51, ns$. Additional analyses revealed an increase in verbatim memory for incongruent items between the no-load and medium-load conditions, $\Delta G^2(1) = 6.28, p < .05$, and a decrease between the medium-load and high-load conditions, $\Delta G^2(1) = 4.21, p < .05$. No difference was observed between the no-load and high-load conditions, $\Delta G^2(1) < 1, ns$. These results again strongly support the notion of an inverted-U pattern of the verbatim incongruency advantage. Summing up these findings, cognitive load interacted with item congruency in the manner predicted by the modified EFM.

Gist memory. Gist memory was not affected by type of test probe, $\Delta G^2(6) = 8.96, ns$. For the sake of simplicity, we again collapsed across this factor for the subsequently reported analyses after initial tests revealed that this procedure did not affect the pattern of results. An overall incongruency advantage in gist memory was found, $\Delta G^2(3) = 51.44, p < .05$. This held under the no-load, $\Delta G^2(1) = 13.41$, the medium-load, $\Delta G^2(1) = 17.06$, and the high-load conditions, $\Delta G^2(1) = 20.97$, all *ps* $< .05$. An effect of cognitive load on the overall level of gist memory was observed, $\Delta G^2(4) = 11.53, p < .05$, that was small but significant for both incongruent items, $\Delta G^2(2) = 6.26$, and congruent items, $\Delta G^2(2) = 6.26$, both *p* $< .05$. Post-hoc

tests revealed a decline with increasing cognitive load: Whereas no difference was found between the no-load and medium-load conditions, both $\Delta G^2(1) < 1$ *ns*, parameter estimates tended to be reduced when comparing the medium-load and high-load conditions; this effect did not reach significance for congruent items, $\Delta G^2(1) = 3.59$, $p = .06$, but did so for incongruent items, $G^2(1) = 4.03$, $p < .05$. Thus, some evidence for detrimental effects of cognitive load on gist memory were obtained.

Guessing. Instruction effects on guessing tendencies were observed, $\Delta G^2(6) = 59.93$, $p < .05$, both on guessing for congruent items, $\Delta G^2(3) = 17.83$, and for incongruent items, $\Delta G^2(2) = 42.10$, both $p < .05$. The tendency to accept probes for which no memory is present was again stronger for congruent than incongruent items, under the T as well as the R instructions, $\Delta G^2(3) = 445.43$, and $\Delta G^2(3) = 250.24$, both $p < .05$. Cognitive load affected guessing biases for congruent items, $\Delta G^2(4) = 19.32$, and for incongruent items, $\Delta G^2(4) = 31.50$, both $p < .05$.

Discussion

The predictions were again confirmed in Experiment 2. The inverted-U-shaped relation between cognitive load and the perceptual incongruency advantage that we obtained in Experiment 1 was replicated, strengthening support for the EFM in its modified version. Results also show a decrease of the incongruency advantage under highly disruptive load that is again incompatible with the original version of the EFM, as extended to the verbatim – gist dimension. The incongruency advantage in gist memory estimates obtained in Experiment 1 was replicated. Similarly, effects of cognitive load on gist memory were again weak. Gist memory was reduced by cognitive load in the high-load condition. This is in contrast to Experiment 1, where a reduction was observed in the moderate digit-load condition. Guessing tendencies again exhibit a strong expectancy bias.

In sum, the results confirm the prediction that the inverted-U pattern predicted by the modified EFM was not due to qualitative differences in cognitive load. Instead, they demonstrate that varying cognitive load along the quantitative dimension is sufficient to obtain the predicted pattern.

A possible alternative explanation for the verbatim memory advantage for incongruent information lies in the materials we used. Specifically, it might be the case that the sentences describing script-incongruent behaviors were on average more attention-grabbing in themselves. For example, they might be more distinctive, or more concrete, or more novel, than sentences describing script-congruent behaviors. If this was the case, sentences describing script-incongruent behaviors might have been encoded in more detail than script-congruent sentences merely because of these confounded stimulus properties. Thus, items' congruency or incongruency with the respective action script schemata might not be the only factor underlying the different patterns of parameter values, and conclusions with regard effects of schema congruency would be inappropriate. We tested this possibility in a follow-up study in which we replicated the medium-load condition from Experiment 2 but without the script context: Instead of reading the sentences as part of a coherent, script-related story, participants were presented with the sentences in a random order without any script context. This procedural modification should remove any effects of congruency or incongruency with the action script schemata. If the results obtained in Experiments 1 and 2 were merely due to possible confounds as discussed above, we would expect no effect of this procedural modification. If, however, congruency and incongruency with schemata was an important factor underlying the effects obtained in Experiments 1 and 2, the absence of schema (in)congruency should be reflected in a reduction of the verbatim memory asymmetry.

The results of this follow-up study confirmed the central role of schema incongruency: When the script context at encoding was removed, there was no longer a verbatim memory advantage for incongruent over congruent information under medium load ($V = .33$ and $V = .26$, for incongruent and congruent items, respectively, $\Delta G^2[1] = 0.56$ ns). This implies that, if confounds inherent in the stimulus sentences did indeed affect verbatim memory in the present experiments, it was only to a weak and nonsignificant extent. Thus, we conclude that the verbatim memory advantage for incongruent information observed in Experiments 1 and 2 is indeed due to the items' incongruency with the schema activated at encoding.

There is some evidence that the disruption caused by the RIR secondary task was somewhat smaller than that caused by the digit-load and random-generation tasks. Whereas in Experiment 1, verbatim parameter estimates for congruent items were numerically smaller with increasing cognitive load, they remained on approximately the same level in Experiment 2. Similarly, verbatim estimates for incongruent items decreased much stronger under high levels of cognitive load in Experiment 1 than in Experiment 2. Finally, gist memory was affected under moderate levels of cognitive load in Experiment 1, but only under high levels of load in Experiment 2. This asymmetry of absolute levels of disruption is not inherent in the RIR method itself but must be attributed to our specific selection of intervals. The RIR method itself is very flexible, and by adjusting the interval parameters, levels of disruption can likely be obtained that are equivalent to those of other secondary tasks. Thus, for future studies that plan to investigate more precisely the threshold of cognitive load up to which the attention-reallocation mechanism still operates, the RIR method is clearly a very useful tool.

General Discussion

The present research for the first time separately assesses the incongruity advantage in verbatim and gist memory. Using a model-based approach, we were able to disentangle encoding of surface detail, as measured by verbatim memory parameters, and of conceptual meaning, as measured by gist memory parameters, in their contribution to memory for expectancy-congruent and expectancy-incongruent information within the same task.

Dissociable effects of cognitive load were observed on verbatim memory processes for congruent and incongruent information in Experiment 1. When participants rehearsed an eight-digit number, a relative increase of verbatim memory was observed for incongruent but not for congruent information. However, when participants generated random digit sequences as a secondary task, this incongruity advantage in verbatim memory was eliminated. Both effects were replicated in Experiment 2 that held the type of secondary task constant but manipulated the difficulty of the task, and thereby the magnitude of the cognitive load it imposed. When secondary task load was moderate, a relative increase of verbatim memory for incongruent information was observed, whereas when secondary task load was strong, this verbatim incongruity advantage was no longer evident.

As a component of our integrative model, the present research investigated the predictions of a modified EFM account of the incongruity advantage in recognition memory (Sherman et al., 1998) as extended to the verbatim – gist distinction proposed by the FTT. According to the EFM, cognitive load causes attentional resources to be reallocated towards the encoding of perceptual detail of incongruent information. Therefore, under cognitive load conditions, perceptual encoding of incongruent information should increase relative to perceptual encoding of congruent information. Thus, a perceptual incongruity advantage that is evident

under conditions of full cognitive capacity should increase in magnitude with increases in cognitive load.

In a number of studies, evidence for this mechanism has been demonstrated (Sherman et al., 1998, 2004). However, our own previous research on the incongruency advantage in recognition memory (Stahl, 2004, 2006) led us to believe that there might be a limit to the level of cognitive load under which this reallocation mechanism can still be of effect. In the present research, we put forward and tested a modified version of the EFM account, incorporating such a limit. We believe that attention-reallocation, as a mechanism of cognitive control, is itself dependent on cognitive resources and can thus only operate when a certain – small but sufficient – amount of resources remains available. Thus, under highly disruptive cognitive load, we expect that this mechanism fails to favor the detailed encoding of incongruent over congruent information.

As discussed above, the results are consistent with our predictions. We found supporting evidence for the attention-reallocation mechanism *under moderate levels* of cognitive load. When cognitive load was moderate, an increase in the magnitude of the verbatim memory advantage for incongruent information was obtained. In addition, we failed to find evidence for the attention-reallocation mechanism under *high* levels of cognitive load. This lends support for an attention-reallocation mechanism as predicted by the EFM, with the limitation that, at least when applied to the verbatim – gist dimension, it is effective only under moderate levels of cognitive load.

Gist memory was higher for incongruent items in both Experiments, and cognitive load significantly reduced gist memory for incongruent but not for congruent items. Both findings are

consistent with the AE framework's prediction of increased conceptual elaboration of incongruent information when sufficient resources are available.

The present results pose problems for both the AE and the EFM. Contrary to AE predictions, moderate levels of cognitive load did not decrease but increase the verbatim incongruency advantage. Contrary to EFM predictions, this increase was not observed under high levels of cognitive load. An integrative model combining both accounts can completely accommodate the present results. The AE framework accurately describes the effect of attention allocation and subsequent elaboration on encoding and memory, as evident in the gist incongruency advantage and its decrease under cognitive load. Simultaneously, the modified EFM can account for the shift in attention allocation toward expectancy-incongruent information under moderate levels of cognitive load that manifested as a verbatim incongruency advantage. Taken together, these predictions account for the inverted-U-shape of the relation between cognitive load and the perceptual encoding advantage for incongruent information in individuals with limited cognitive capacity. We conclude that the AE framework, supplemented by an attention-reallocation mechanism as proposed by the modified EFM, provides a plausible explanation for the present data.

CONCLUSION

In two experiments, we consistently observed an increase in the perceptual recognition memory advantage of expectancy-incongruent information compared to congruent information under moderate levels of cognitive load. This effect was a function of the amount of cognitive resources available to subjects and did not depend on the type of secondary task and thus the quality of cognitive load. These results firmly support the notion of an attention-reallocation mechanism as postulated by the EFM. However, the conditions under which the attention-

reallocation mechanism affects encoding processes in the CR paradigm are clearly limited. We have consistently shown in two experiments that this mechanism is effective only under conditions of moderate cognitive load, and that it fails to affect encoding under high levels of cognitive load. In sum, the present results lend considerable support to the modified EFM. Future research will need to examine the anatomy of the attention-reallocation process in order to understand the underlying causes of its breakdown under high-load conditions. An integration of the modified EFM with the more general AE framework fares well in accounting for the entirety of the present data. Beyond the present results, it also represents a parsimonious and intuitive account of the relation between attention, elaboration, and memory.

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Footnotes

¹ The incongruency advantage in recognition memory appears to be a somewhat unstable phenomenon. In our lab, several attempts to obtain an incongruency advantage failed: In two studies in the gender-stereotype domain (e.g., Macrae et al., 2002) and two additional studies in the domain of social stereotypes (e.g., Ehrenberg, 2002; Ehrenberg & Klauer, 2005; Sherman et al., 1998) we did not find an incongruency advantage.

Tables

Table 1.

Parameter Estimates (and 95% Confidence Intervals) for Verbatim and Gist memory and Guessing Bias from Experiment 1.

	Congruent			Incongruent		
	No Load	Digit Load	RNG	No Load	Digit Load	RNG
<i>V</i>	.43 (.28 .58)	.36 (.22 .51)	.21 (.05 .37)	.52 (.39 .66)	.65 (.53 .77)	.31 (.16 .46)
<i>G</i>	.34 (.21 .48)	.42 (.32 .52)	.31 (.17 .45)	.62 (.55 .70)	.49 (.42 .57)	.51 (.44 .58)
<i>B_T</i>	.45 (.37 .52)	.28 (.21 .35)	.50 (.43 .58)	.02 (.00 .04)	.01 (.00 .03)	.06 (.02 .09)
<i>B_R</i>	.41 (.33 .48)	.29 (.22 .36)	.49 (.42 .57)	.08 (.03 .12)	.06 (.02 .10)	.11 (.06 .16)

Note. RNG: random number generation; *V*: probability of accessing the verbatim trace; *G*: probability of accessing the gist trace; *B_T*: guessing tendency under the T condition; *B_R*: guessing tendency under the R condition.

Table 2.

Parameter Estimates (and 95% Confidence Intervals) for Verbatim and Gist memory and Guessing Bias for congruent and incongruent items under the low, medium, and high cognitive load conditions in Experiment 2.

	Congruent			Incongruent		
	Low	Medium	High	Low	Medium	High
<i>V</i>	.44 (.32 .56)	.37 (.26 .48)	.46 (.36 .57)	.52 (.42 .62)	.69 (.61 .78)	.56 (.46 .65)
<i>G</i>	.38 (.28 .47)	.34 (.25 .44)	.20 (.10 .31)	.57 (.52 .63)	.56 (.50 .62)	.48 (.42 .54)
<i>B_T</i>	.48 (.42 .54)	.36 (.30 .41)	.43 (.38 .49)	.03 (.01 .06)	.01 (.00 .02)	.04 (.01 .06)
<i>B_R</i>	.34 (.29 .40)	.45 (.39 .51)	.44 (.39 .50)	.07 (.04 .10)	.05 (.02 .07)	.17 (.13 .22)

Note. RNG: Random Number Generation; *V*: probability of accessing the verbatim trace; *G*: probability of accessing the gist trace; *B_T*: guessing tendency under the T condition; *B_R*: guessing tendency under the R condition.

Figure Captions

Figure 1. Multinomial processing tree model of the CR paradigm (adapted from Brainerd, Stein & Reyna, 1998). The diagrams depict the cognitive processes postulated for, from top to bottom, target probes, related probes, and unrelated probes. Stimuli are given on the left side of each tree, responses are given on the right (separately for the T and R instruction conditions). Parameters represent the following probabilities: V = access to verbatim trace when target probe is presented; V' = access to verbatim trace when related probe is presented; G = access to gist trace when target probe is presented; G' = access to gist trace when related probe is presented; B = accepting probes by way of guessing. Note that different B parameters (B_T , B_R) are estimated for the T and R conditions.

Figure 1